MONTANA Wildlife

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Montana Wildlife

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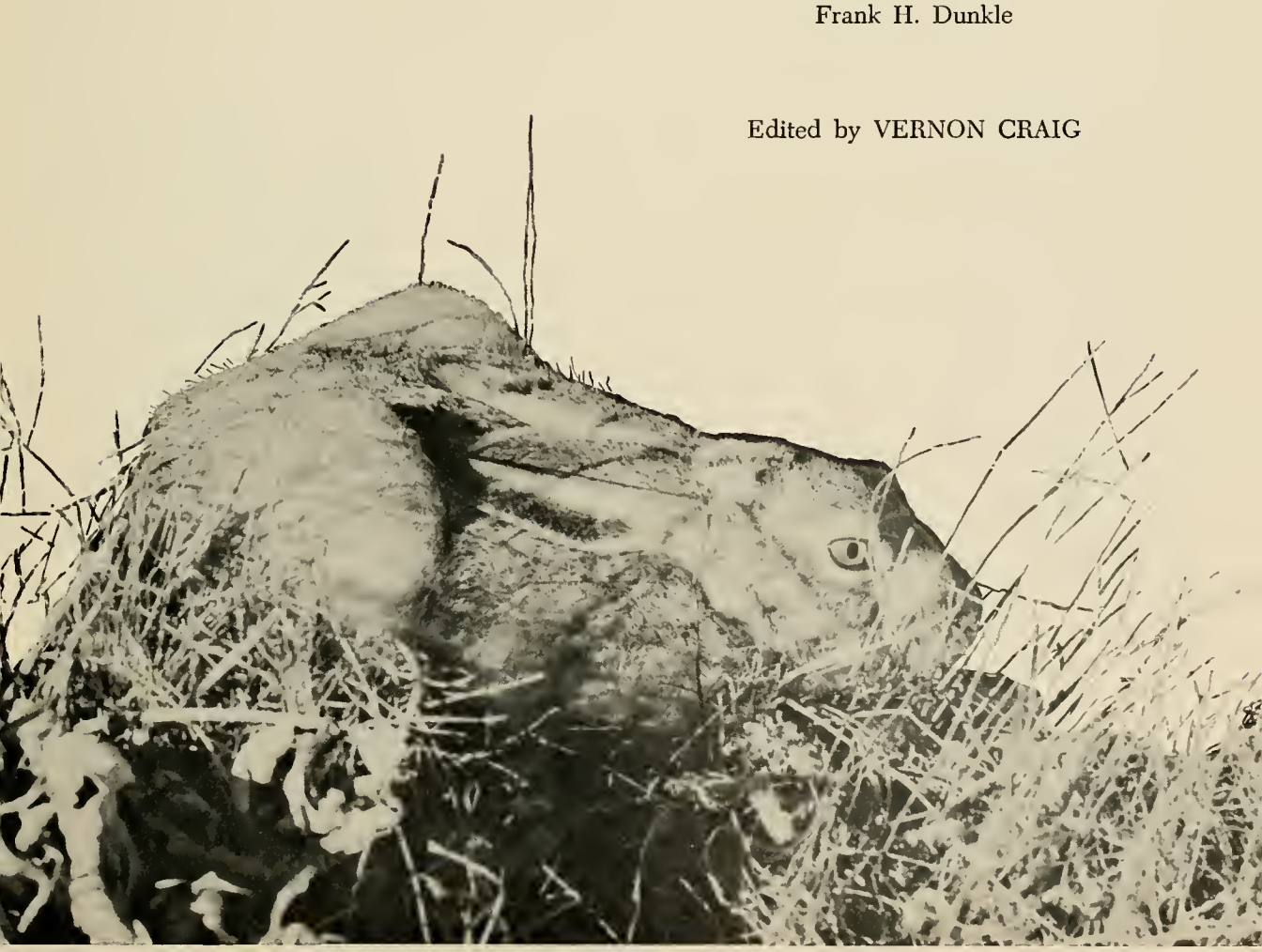

Featuring

Tularemia In Montana

by — Doctor William L. Jellison

Turtles of Montana

by — Jeffrey H. Black

Series 2 of Montana Animals

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About the Authors

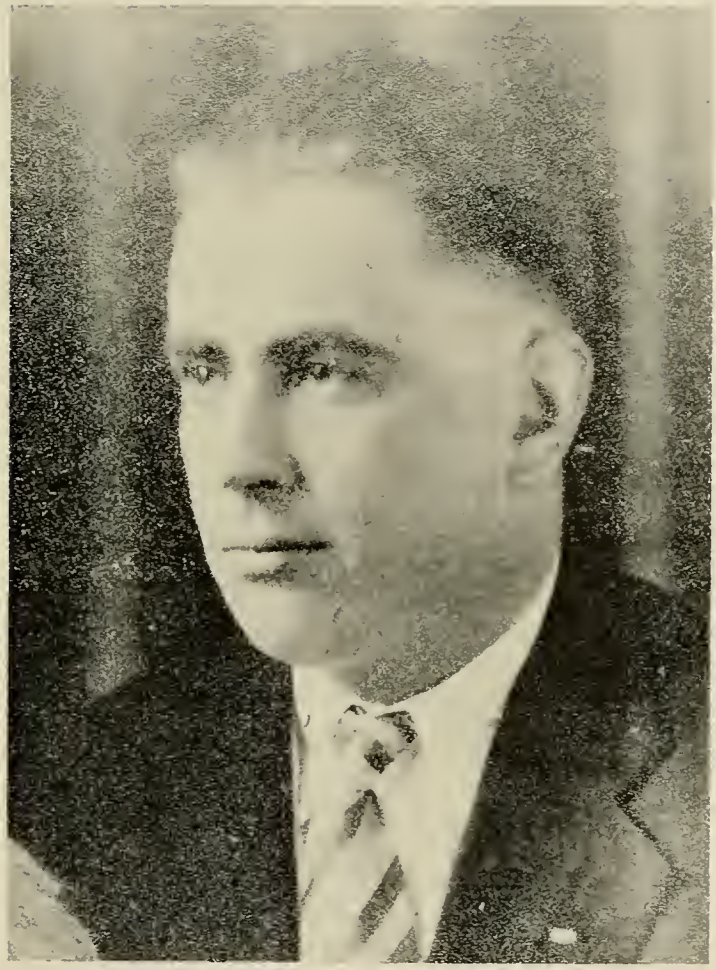
William L. Jellison is a native of Flathead County where he attended rural school and high school. He is a graduate of Montana State University. From 1929 to 1962 he was a member of the staff at the Rocky Mountain Laboratory and engaged in laboratory and field studies of many diseases including spotted fever and tularemia. His work at Hamilton has been interrupted many times for graduate study, military assignments and expeditions to Burma, China, Alaska, Korea, Europe and Argentina.

He retired from the U. S. Public Health Service in 1962 but has remained active in scientific work, civic affairs, teaching at the University, and maintains the Ricketts Memorial Museum at Hamilton.

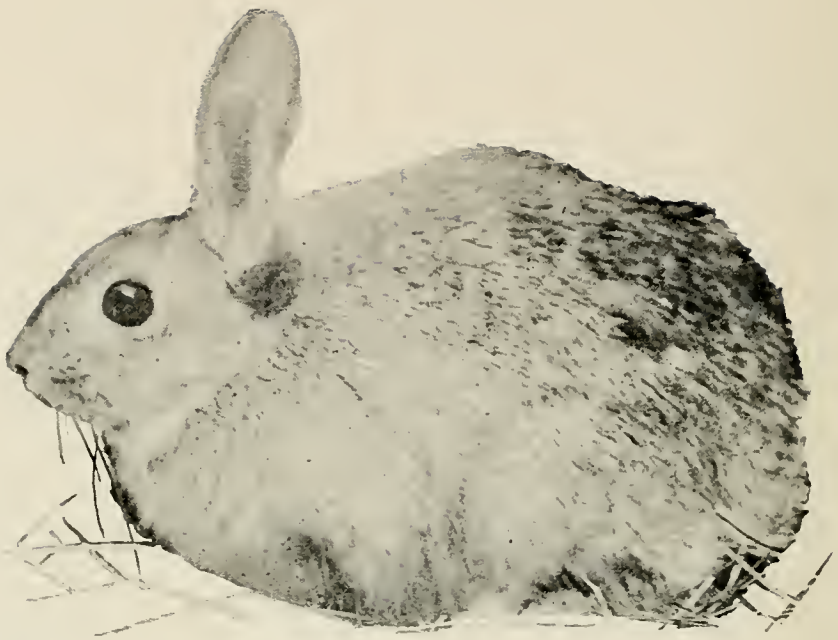
Doctor Jellison had tularemia in 1930 and spent the 4th of July and 16 more days in the Hamilton hospital. Besides contributing almost daily blood samples for laboratory tests, he was set upon several evenings by cages of hungry mosquitoes in order to determine if they could pick up infection from a human case.

Jeffrey Black, now completing Doctorate work at the University of Oklahoma, received his Bachelor of Science from Oregon State University. He worked two years on his Master of Science Degree at the University of Montana, Missoula.

While in Montana, Jeffrey Black traveled more than 40,000 miles to collect information and specimens. He authored "Amphibians of Montana," a MONTANA WILDLIFE issue which featured the first in a series of Montana animals.



Martin Nolan, Rocky Mountain Laboratory technician
who died of tularemia in 1931.



About 90% of all cases of tularemia in the United States probably comes from direct contact with rabbits of some kind.

TULAREMIA IN MONTANA

The Rocky Mountain Laboratory (RML) of the U. S. Public Health Service at Hamilton, Montana, has been a center of tularemia research for about 45 years. Montana with its diversified avian and mammalian faunae has been an excellent area for field and epidemiological observations and these have been supported by intensive laboratory studies. Case finding has probably been more thorough in Montana than in any other state. As a result of these studies both the incidence (rate per 10,000 population), 8.5, and actual number of cases, 576 recorded for Montana, are high in comparison with those of other western states. This combination of circumstances has resulted in considerable advancement of our knowledge of an interesting and highly infectious bacterial disease of man, domestic animals, wild birds and wild mammals.

The first few papers on tularemia were concerned with its presence in ground squirrels in California. Ticks were in no way associated with the disease; however, in the RML, which specializes in the study of ticks and tick-borne diseases, it was inevitable that we became involved in tularemia research. We now know that ticks of several species are frequently infected with the causative organism, **Francisella tularensis**, and in fact are probably the most important vectors among the many arthropods known to carry the organism in nature.

Dr. H. E. Lamb of Gooding, Idaho, gave a talk in 1923 on what he called "Glandular type of tick fever" and which he supposed was an unusual manifestation of spotted fever. His patients had been bitten by ticks and lesions developed at the site of tick attachment. The symptoms and lesions he described were recognized by Dr. R. R. Parker and his associates at Hamilton, as suggestive of tularemia, a disease described and named by Dr. Francis in 1921. By serological tests it was soon demonstrated that Dr. Lamb's patients had been ill with tularemia. This gave a clue for the identification of one of the undiagnosed infections observed in the laboratory animals used for testing ticks. By cultural studies it was soon proved that some of the test guinea pigs and rabbits were dying of tularemia (Parker, Spencer and Francis, 1924). From here on tularemia research was an important part of the RML activities.

HISTORY IN MONTANA

Outstanding episodes of tularemia in Montana because of their historical significance, economic loss or scientific interest are many. Some of these will be discussed in greater detail later.

In the early days of study, many laboratory workers became infected. During 1924 and 1925, six members of professional and technical staff, including the Director, at the Canyon Creek Laboratory, Hamilton, contracted the disease and were seriously ill. Three were ill at one time. Presumably these three became infected when ticks were being removed from an experimental rabbit. One man was only an observer at the operation.

This pattern of infection has occurred at nearly every laboratory that engaged in tularemia research in England, Russia and the United States. Before the development of an effective vaccine, practically everyone actively engaged in tularemia research became infected and there was at least one death. Sixty-five laboratory cases were recorded by 1951 (Sulkin and Pike).

An epizootic in sage grouse at Roy, Montana, in 1931, was associated with heavy infestations of bird ticks, **Haemaphysalis cinnabarina**. An epizootic is an outbreak of disease in animals. Tularemia was present in the grouse and ticks and may have been a major cause of fatalities. **H. cinnabarina** is not usually an abundant tick in Montana.

In 1931, Martin Nolan, a laboratory technician at Rocky Mountain Laboratory, died of tularemia contracted in the laboratory.

In April and May, 1934, an epizootic occurred in sheep at Ringling, associated with heavy infestations of wood ticks, **Dermacentor andersoni**. Over 400 sheep were affected and 200 died. Tularemia was also diagnosed in jack rabbits in the area. There were no human cases involved in this episode, although men were employed in picking ticks from sheep, dipping and even skinning dead sheep. Blood tests indicated none of these men were immune or had experienced previous infection.

A widespread epizootic in beaver and muskrats throughout most of Montana and several other states lasted from 1939 through 1943. Many human cases resulted from contact with these fur-bearing animals. A study of this outbreak resulted in the first isolations of **F. tularensis** from water samples in North America. The first isolates came from ponds along the stream bed on the Musselshell River near Roundup.

A case of intense and persistent septic sore throat with systemic illness near Bozeman was diagnosed as anginal form of tularemia and was attributed to contaminated food or water. A study revealed three other similar cases associated with the same rural, domestic water supply. **F. tularensis** was isolated repeatedly from the kitchen tap. These were among the first and the most definite cases in North America attributed directly to water, although hundreds of cases in Europe and the U.S.S.R. have been attributed to waterborne organisms.

In May, 1964, a dramatic outbreak of disease in mature cattle and calves associated with heavy infestations of wood ticks, **D. andersoni**, occurred at Big Sandy. Tick paralysis affected most of the animals but a diagnosis of tularemia was established in two sick calves and in three lots of ticks from three calves. At least 30 mature animals were affected and we were informed 12 cows and four calves died. Losses were accentuated by severe storms which further weakened the animals and handicapped rescue and care of animals out on the range. We had studied severe outbreaks of tick paralysis in cattle and of tularemia in sheep but both diseases appeared in this epizootic.

Concurrently with the epizootic in cattle at Big Sandy, May, 1964, and during the same storm, severe losses and illness in young lambs and ewes and many abortions were experienced on numerous ranches near Jordan. The sheep were heavily infested with wood ticks, **D. andersoni**. **F. tularensis** was isolated from one dead ewe and tularemia was diagnosed in many convalescent sheep by the agglutination test. Some sheep were apparently affected by tick paralysis only. Ranchers in the area later provided the following estimate of losses: lambs—991, ewes—824, yearlings—108, and bucks—4.

Male Female

Rocky Mountain wood tick, Dermacentor andersoni, an important carrier of tularemia in nature.

Since the first studies on tularemia in sheep in nature by Parker and Dade (1929) there has been confusion between tick paralysis and tularemia in these animals. In all sheep epizootic studies where I have participated, tularemia appeared to be the main cause of disease but in the Jordan outbreak there were certainly some cases of tick paralysis.

Tularemia was demonstrated in one mare and five foals near Belgrade by Claus, Newhall and Mee (1959) of the Veterinary Research Laboratory at Bozeman and the Veterinary Hospital at Belgrade. All animals were heavily infested with **D. andersoni.** Two foals died and **F. tularensis** was isolated from their tissues. The mare and three surviving foals had received antibiotic treatment. This appears to be the first and only report of tularemia in horses in North America.

EPIDEMIOLOGY IN RELATION TO CERTAIN ANIMALS

In 1945, Jellison and Parker published a paper which attempted to clarify some of the concepts about epidemiology of tularemia. Until that time and in many instances since 1945, practically every general paper on tularemia defined it as "a disease of wild rodents transmissible to man." Technically this is only partially correct. For a long time zoologists classified all the rabbits with the rodents but in a separate suborder. Zoologists are now in general agreement that the rabbits deserve a separate order, Lagomorpha. Rabbits are as distinct from true rodents, such as rats, mice, porcupines and squirrels, as they are from sheep and cattle. They differ from the true rodents in arrangement of teeth, bony structure, internal anatomy and biology. They also differ markedly in their parasites, diseases and reactions to diseases.

Available statistics (1945) showed that about 90% of all cases of tularemia in the United States came from direct contact with rabbits of some kind. Therefore, it would be more accurate to state "tularemia in North America is primarily a disease of wild rabbits and to a lesser extent of wild rodents and is transmissible to man." Quite a few cases do come from contact with muskrats, beaver, ground squirrels and tree squirrels which are true rodents.

Jellison and Parker further emphasized that among the rabbits it is the cottontails, **Sylvilagus** spp., that are the principal source of infection. By a series of maps it was clearly demonstrated that there is a close relationship

between the geographical distribution of cottontails and that of tularemia in all of North America. No comparable geographical relationship is recognized for any other kind of wild rabbits. Domestic rabbits are unimportant as a source of human infection in nature.

In 1945 records were available for over 14,000 cases in the United States and only 38 or 39 for all of Canada. The northern limit of cottontail distribution closely follows the Canadian border from Washington to New York. Tularemia was conspicuously absent from New England and the Pacific Northwest, west of the Cascade Mountains. Cottontails are rare or absent in these areas. In central states where there is the greatest concentration of cases, no other kind of wild rabbit is present.

Among the rabbits, it is the cottontails that are the principal sources of tularemia infection.

Map below shows distribution of certain cottontails in North America—from Hall, 1951.

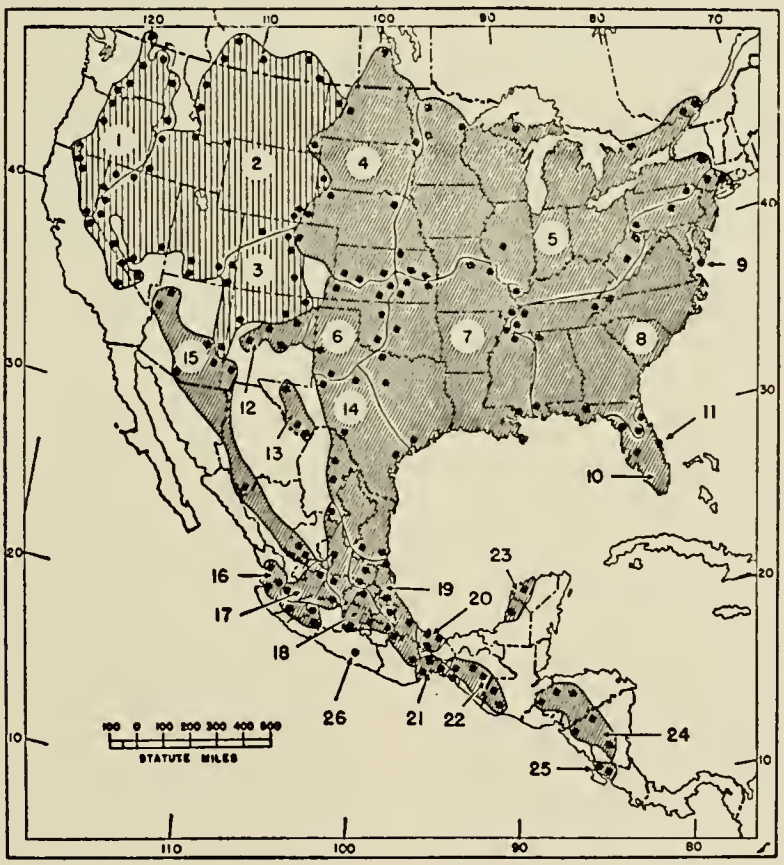


FIG. 39. Distribution of *Sylvilagus nuttallii*, *S. floridanus* and *S. insonus*.

Guide to kinds:
1. *S. n. nuttallii*
2. *S. n. grangeri*
3. *S. n. pinetis*
4. *S. f. similis*
5. *S. f. mearnsi*
6. *S. f. llanensis*
7. *S. f. alacer*
8. *S. f. mallurus*
9. *S. f. hitchensi*
10. *S. f. floridanus*
11. *S. f. ammophilus*
12. *S. f. cognatus*
13. *S. f. robustus*
14. *S. f. chapmani*
15. *S. f. holzneri*
16. *S. f. restrictus*
17. *S. f. subcinctus*
18. *S. f. orizabae*
19. *S. f. connectens*
20. *S. f. russatus*
21. *S. f. aztecus*
22. *S. f. chiapensis*
23. *S. f. yucatanicus*
24. *S. f. hondurensis*
25. *S. f. costaricensis*
26. *S. insonus*

The periodic, dramatic die-offs of snowshoe hares are well known, but it has never been proven that tularemia is an important factor in their "cycles."

There is a group of rabbits present in southern and eastern United States known as swamp rabbits, subgenus **Tapeti** of the genus **Sylvilagus**, whose role in the epidemiology of tularemia has not been determined or recorded in the literature.

By 1945, about 50 of the 14,000 cases had been attributed specifically to contact with jack rabbits. The organism has been isolated from sick and dead jack rabbits which probably are an important source of infection for ticks and deerflies which carry the disease to man.

Tularemia may be a very important factor in the ecology of jack rabbits, especially at times of widespread epizootics, but we have yet to study such a die-off in which tularemia appeared to be a significant cause of mortality.

Although intensive studies have been made on snowshoe hares in the United States and Canada, it has never been proven that tularemia is an important factor in their periodic die-offs and snowshoes are unimportant as a source of human infection. Clinical cases from rabbit contacts are still uncommon in New England, Canada, and Alaska where snowshoes are abundant and are shot and trapped by the millions for human food.

EPIDEMIOLOGY IN RELATION TO CERTAIN MONTANA ANIMALS

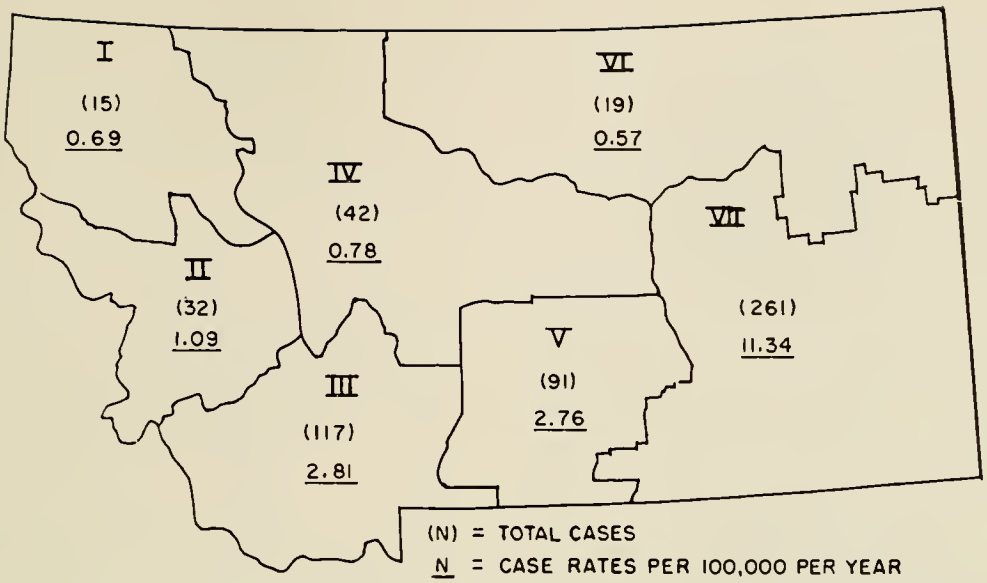
The distribution patterns for rabbits referred to previously have some application to Montana, since we have all three types, cottontails, snowshoes, and jacks, within the state. Snowshoes are present in the western half of the state, mainly in the mountains, and in the northeastern corner; cottontails appear to be present in every county with the possible exception of those in the northwest corner of the state; jack rabbits are widely distributed in Montana but also seem to have been absent from the northwest corner, although there are recent records for Flathead County by Hoffman, Wright and Newby (1969).

As a native of the upper Flathead Valley, I would say cottontails and jack rabbits were not indigenous to Flathead and Lincoln Counties or to the western part of Glacier Park. The northern limit to their distribution west of the Continental Divide appears to have been about St. Ignatius, Post Creek, Charlo, Moiese and Hot Springs. A field party from RML collected a specimen about two miles north of Moiese, October 16, 1944, and they are present around buildings on the Bison Range at Moiese.

Tularemia cases are conspicuously rare in Flathead and Lincoln Counties and Glacier Park, west of the divide. Laboratory records show the five cases recorded for Flathead were in 1924, 1; 1945, 2; 1950, 1; and 1951, 1. The three for Lincoln County were 1952, 1; 1955, 2. It is possible some of these were contracted elsewhere.

About 1945, cottontails appeared in the upper Flathead and were frequently seen on our ranch at LaSalle. An adult specimen was collected there by Charles Jellison in February, 1945. It was rumored that a shipment of cottontails had been brought into the valley and liberated by sportsmen but this is not documented. Cottontails are now common on Angel Point, near Lakeside, and possibly, other places in the valley. This population may represent an extension of their range northward from Lake County or, possibly, intentional introduction. I do not know of any record for Lincoln County although I have made inquiries on this subject.

I found a freshly dead young rabbit near the Flathead River on the home ranch at LaSalle, September 9, 1937. It exhibited lesions on the spleen and liver suggestive of tularemia and tissues taken to the RML yielded cultures of **F. tularensis**. I was never



Tularemia cases and case rates by Fish and Game Administrative Districts, 1925-1964. (From Philip, Casper and Lackman, Journal of Infectious Diseases, 1967.)

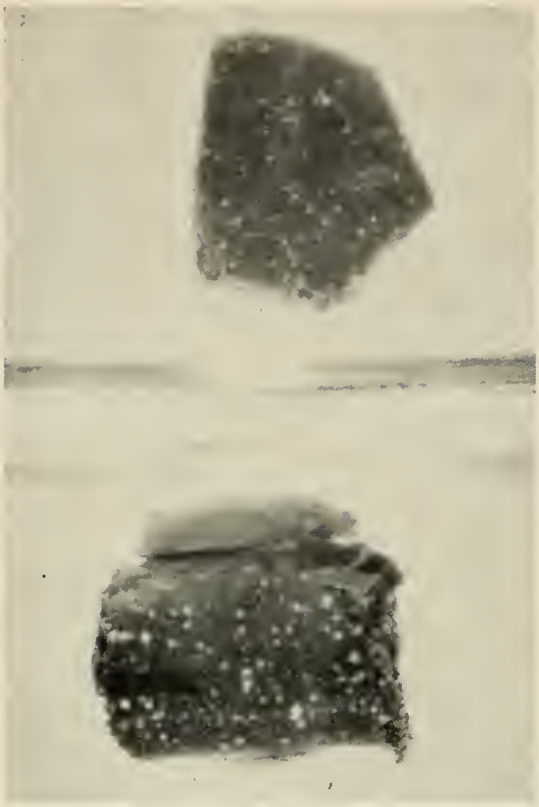
certain whether this was a young cottontail or a snowshoe, as it was in summer pelage. As far as I know, this is the only isolate of **F. tularensis** from any source in this northwest corner of Montana.

Muskrats and beaver are abundant in Flathead and Lincoln Counties. I can see no reason why tularemia should not be as prevalent in beaver and muskrats in Flathead and Lincoln Counties as it is in Lake, Missoula, and Ravalli, since this form appears to be entirely independent of cottontails and ticks. An outbreak of tularemia in beaver and muskrats was reported in Waterton Lakes National Park, Canada, just north of Glacier Park, by Langford (1954).

We did study one outbreak of disease in beaver in the Whitefish area, Flathead County in 1961. Many fresh carcasses and fresh hides were examined and tissues were tested in laboratory animals. Skin abscesses and damage to pelts were more prominent than fatalities. We found no lesions characteristic of tularemia, failed to establish tularemia or any other infection in laboratory animals, and we did not arrive at any satisfactory diagnosis. The winter weather had been exceedingly mild in the area and may have had some relationship to the outbreak. (Reported in Daily Interlake, Kalispell, April 4, 1961.) The belief persisted that this was an outbreak of tularemia regardless of our studies and reports. Several of us engaged in the study had just participated in field and laboratory work on an epizootic in field mice in Oregon, where 187 separate isolates of **F. tularensis** were established, so we were not unfamiliar with the disease and organism.

Hunters, trappers, ranchers, county agents and game wardens are valuable sources of information when one is investigating animal diseases. They are often keen observers and in close contact with nature. However, their interpretation of what they observe is sometimes erroneous. In this respect they do not differ from "scientists and experts." If one is interviewing hunters and trappers regarding diseases in animals, one standard reply is, "Oh yes, I recognize tularemia in a rabbit when I see it. It produces large water blisters under the skin." **This just is not so.** The large water blisters under the skin, in the flesh or among the visceral organs of rabbits are larval stages of tapeworms of several species. These develop into typical tapeworms in the intestines of coyotes, bobcats or other wild and domestic carnivores. They are not usually harmful to the rabbit host.

The characteristic lesions of tularemia are small to medium greyish-white foci on the spleen and liver and sometimes on the lungs of infected animals. There are several bacterial diseases that produce lesions so similar to these that they cannot be distinguished



Characteristic lesions of tularemia on liver (above) and spleen of laboratory animal.

with certainty even by a laboratory worker with much experience. Demonstration of the organism in microscope slides aids in diagnosis but is not definite. Confirmation can be established only by isolation of the organism in culture, either direct or after animal passage. In many animals, including wild mice, birds, carnivores and sheep, the lesions are indistinct and even presumptive diagnosis is difficult. **Animals found dead in nature or those obviously sick should be regarded with great suspicion and contact should be avoided except to dispose of the animal as safely as practical or else saved for laboratory examination.**

EPIDEMIOLOGY IN MONTANA

The best summary of tularemia cases in Montana was presented by Philip, Casper and Lackman (1967) from records of the Rocky Mountain Laboratory and the Montana State Board of Health. Data were available for 576 cases that occurred from 1925 through 1964. Most of them (87%) occurred in the southern half of the state. About 50% of the cases were in 11 southeastern counties of the 56.

These cases were separated into two groups on the basis of source of infection: Ticks, rabbits or sheep were responsible for 326 or about 82% of the 400 cases where source of infection was known. Muskrats, beaver or water were responsible for the remaining 18%.

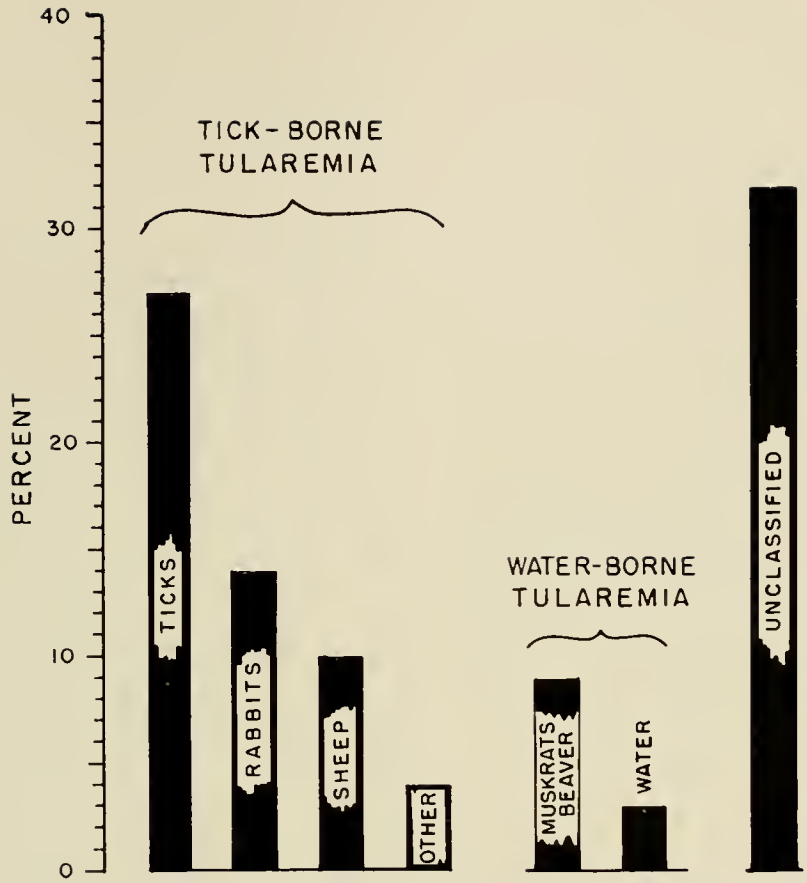
In Western, Middle, and Eastern Montana there is a decline in cases from south to north with the conspicuous exception of Garfield County, which is about in the center of the state. This decline is less marked in the west, where infection is often attributed to muskrats and beaver, than in the east, where infections are caused by contact with ticks, rabbits, or sheep.

In a map prepared by Philip and Casper (1969) 14 counties have an annual case incidence of over 0.5 per 10,000 in the years 1925-1964. Twelve of these counties are in the southern half of Montana, the exceptions being Petroleum and Garfield in central Montana. Not a single county in the northern tier of states has such an incidence of 0.5 or over.

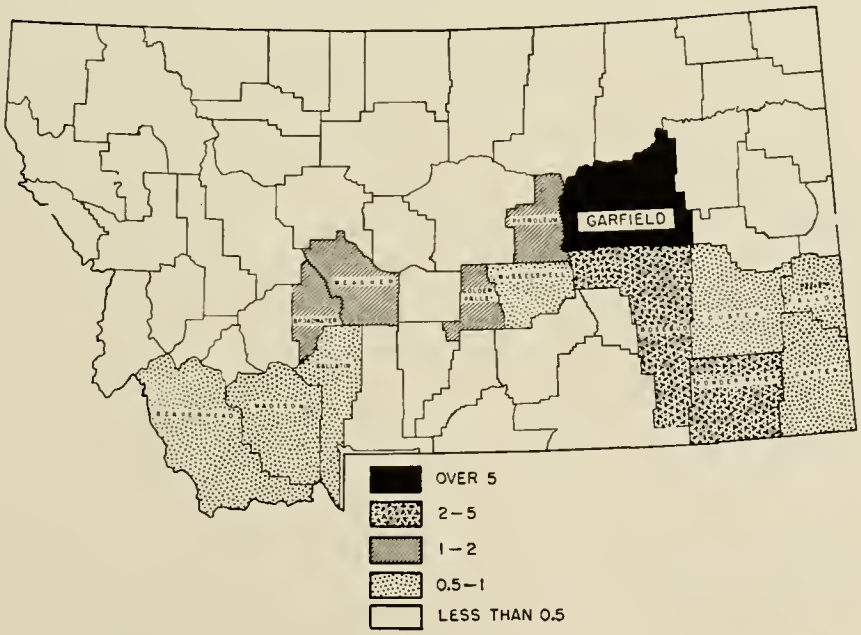
I would associate this case distribution to the abundance or scarcity of cottontails, whose northern limit of distribution approximates the Montana-Canadian border. Cottontails certainly decrease in abundance and in territory occupied as they approach their northern limit of distribution in Montana, but this is not documented with reliable statistics. Such a relationship between cases and cottontail distribution was indicated in a series of maps by Morgan (1949) for Wisconsin and by Yeatter and Thompson (1952) for Illinois.

DECLINE IN CASES FROM SOUTH TO NORTH BY COUNTIES

SOUTH	Ravalli—13	Carbon—14	Carter—12
INTERMEDIATE	Lake—5 Flathead—5	Wheatland—3 Judith Basin—1	Fallon—15 Wibaux—0 Richland—1
NORTH	Lincoln—3	Hill—3	Sheridan—0



Tularemia, Montana, 1925-1964. Percentage distribution of cases by probable source of infection.



Average annual tularemia case rate per 10,000 population, Montana, 1925-1964. (From Casper and Philip, Public Health Reports, 1969).

PROBABLE NUMBER OF CASES

We assume that there are many cases of tularemia that are not reported to health officials and do not get into the records. There are certain ways of projecting sound statistical data to support this assumption.

Whenever a few cases are reported in a limited area by physicians, an epidemiological study and interviews with physicians and patients usually identifies additional current cases and others that occurred many years previously.

In early years it was obvious that more cases were reported in states or around centers where there were active research projects on tularemia such as Ohio, Montana and Washington, D.C. Although epidemiological reporting has greatly improved, this still may be true not only of tularemia but other diseases. In a distribution map prepared by the U. S. Public Health Service and published by Simpson (1929) recording 806 cases the leading communities were:

	STATE	CASES
1	Ohio	92
2	Montana	66
3	Tennessee	51
4	Washington, D. C.	45
5	Missouri	39
6	Mississippi	39
7	Illinois	38

This was greatly changed by 1948 when a map published by Jellison, Owen, Bell and Kohls showed the eight leading states were:

	STATE	CASES
1	Illinois	2905
2	Ohio	1478
3	Arkansas	1407
4	Missouri	1396
5	Virginia	1363
6	Kentucky	1315
7	Georgia	1189
8	Tennessee	1101

Montana ranked number 22 with 354 cases.

By 1955 there were records, based on physicians' and State Health Department reports, of 64 cases in sheep-shearers. Extensive surveys of sheep-shearing crews accompanied by interviews and blood samples identified 31 cases. Not one of these had been reported through regular channels. Had three or four of these been included in both records, it would have given a basis for calculation (Lincoln Index) of the probable total cases in shearers.

As another example, Casper and Philip (1969) made a special study in Garfield County, a large area of sparse population, about 1,981 people, which has reported 58 cases of tularemia. This is more than any other county except Rosebud (62 cases) which is immediately south of Garfield. Third in number is Powder River (30 cases) in southeastern Montana. Most of the cases in Garfield County have been reported by Dr. Ferrand, County Health Officer, a long-time resident of the County Seat, Jordan, the only physician in the county and one who has been familiar with the disease for many years.

Following the 1964 epizootic in sheep and concurrent cases in sheep industry workers, Casper and Philip presented the following statistics: four of the 12 patients did not seek medical care and would have been missed except for the intensive survey. In a skin-test survey, 24 persons were found to react to **F. tularensis** antigen and only four of those had been diagnosed previously. These authors concluded, "If the population tested was representative of the total population, the true incidence of tularemia infection in Garfield County was five times higher than reported."

With the advent of effective antibiotics for treatment of tularemia it is reasonable to assume that case reporting is even more neglected by physicians.

A recent report (Anon., 1970) from the Public Health Service, received while this manuscript was in preparation, gives the following information.

For the nine-year period, 1960-1968, a total of 2,594 cases of tularemia were reported in the United States.

During the eight-year period, 1960-1967, 23 deaths attributable to tularemia were reported for a case fatality rate of 0.96 per cent. In the decade prior to 1946, the case fatality rate had been 9.5 per cent.

The decline in mortality probably reflects both the decline in morbidity and the availability of streptomycin after September, 1946.

TULAREMIA IN SHEEP

Among the more spectacular manifestations of tularemia are the occasional devastating epizootics in domestic sheep that have been observed in Montana, Idaho, and at least once in Alberta. Practically every outbreak has been studied at the RML, and all of these have several features in common. The sheep are out on range land in early spring, they graze through an area where wood ticks are abundant and pick up a heavy infestation of ticks. Presumably, an epizootic of tularemia has been present here in rabbits the previous summer and left behind a large number of ticks infected with very virulent strains. Within a few days sheep start dropping out of the band, sicken and die. By this time the band may be miles from the real tick-infested area. Within a few days, half the band may be sick and 10% will die.

Prompt attention with manual removal of ticks, dipping, spraying and dusting along with supportive care will save many sheep. In one instance antibiotics were administered with apparent beneficial effect. Adverse weather conditions which are frequent at this time of year complicate the situation and lead to losses of hundreds of animals.

According to the few laboratory tests that have been made, sheep are quite resistant to tularemia infection but a combination of heavy infestation with ticks, many of which are infected, reduced vitality after a long winter, shortage of feed and early spring storms seem to overcome this natural resistance. Very sick sheep may respond to tick removal, food and shelter and eventually recover.

Loss of a few range sheep in the spring of the year, especially at lambing time, out of bands numbering in the hundreds or thousands does not attract particular attention. Possibly many of these sporadic losses are due to tularemia, but we have little information on this point. When a real epizootic strikes, the loss is too serious to be overlooked but in some instances information on such outbreaks has been weeks or months in reaching our laboratory. Whenever practical, an immediate on-the-spot-study has been made. We

Sick animals left behind from a band of sheep near Ringling, 1934. About 200 sheep died of tularemia.

have been aided in these studies by the fact that the agglutination reaction is very persistent in sheep and a reasonably certain diagnosis can be established in surviving animals months after the epizootic. Serological tests were used to study several epizootics in Idaho and in the 1964 outbreak in Jordan. Before shearing, convalescent animals may also be conspicuous by severe damage to their fleece. Severe illness of any kind causes a "break" in the wool and part or the entire fleece may be shed. A broken fleece is only an indication of illness, which may or may not have been tularemia.

It is understandable that sheep owners who have had experience with quarantine and enforced dipping are reluctant to report disease to health or veterinary authorities, but in the case of suspected tularemia prompt reporting and diagnosis could help to avert serious losses. We have also experienced some reluctance among biologists, game managers and wild life administrators to report animal disease in their jurisdiction.

Up until 1955, we had records of 189 cases of tularemia in people associated with the sheep industry. At least seven of these were fatal. This included herders, owners, and shearers. It was quite conspicuous that none of these cases in the United States and only one in Canada were associated with acute outbreaks in sheep. At such times men are working picking ticks by hand, dusting, dipping, or spraying the flock, treating sick animals and even skinning the dead ones and so are grossly exposed to infection. We have no explanation for this apparent lack of transmission. However, in the 1964 epizootic at Jordan, Garfield County, there were at least 12 acute cases among those employed in the sheep industry. Some of the sick owners and herders were trying to treat and care for their flocks during the storm when they should have been in the hospital.

A summary of our studies on tularemia in sheep was published as a Public Health Monograph in 1955 (17 pages) and copies are still available.

TWO KINDS OF TULAREMIA

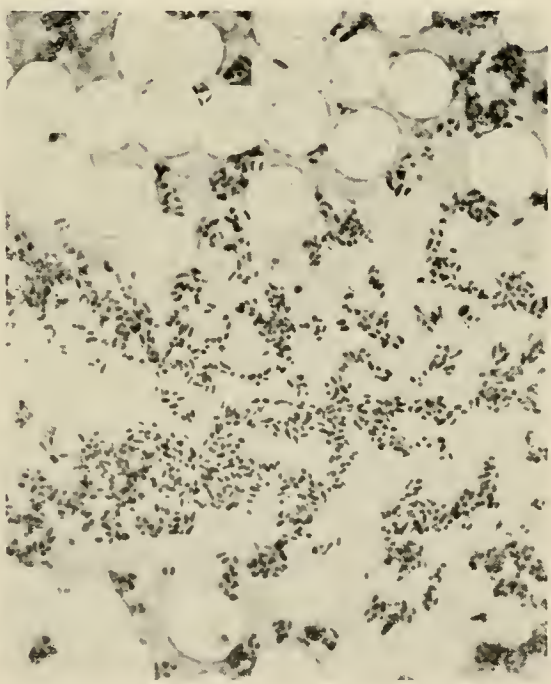
The epidemiology of tularemia was greatly clarified when research workers at Hamilton

Pelts, carcasses and sick sheep at Ringling epizootic, 1934.

Lamb with badly broken fleece after recovery from tularemia.

and in Russia reached the conclusion that there are at least two distinct kinds of tularemia. These two differ in mode of transmission and virulence and the respective causative organisms have minor cultural differences. One kind is associated with rabbits, is frequently transmitted by ticks, is more virulent, is the common type for human infection in the United States and insofar as we know is limited in distribution to North America. This type in man was 5% to 7% fatal before effective antibiotics became available for treatment.

The second type is mainly associated with true rodents (order Rodentia), i.e., muskrats. field mice and beaver in the United States and Canada and with water rats (a small muskrat like mammal) and mice of many kinds in Russia and Siberia. It is also associated with hares and rabbits in Scandinavian countries, continental Europe, Russia, and Japan. This kind is of lesser virulence, is rarely or never fatal to man, and is highly fatal for rodents, often appearing in devastating epizootics in muskrats, voles, beaver, and water rats. It is sometimes transmitted by ticks and



Tularemia organisms, small dark bodies, and red blood cells, large white discs, in blood smear from a vole, Microtus montanus.

is frequently associated with water where it appears to be independent of arthropod transmission. During epizootic periods and frequently in the absence of any observed mortality in animals, the organisms can be isolated from water of streams, ponds and rivers by injection of samples into laboratory animals. We assume wild animals become infected from the water and also by cannibalism.

The Russian scientists have proposed separate subspecific names for the organisms causing the two types, **Francisella tularensis tularensis**, the North American type; and **Francisella tularensis palearctica**, the more widespread type. Both types of tularemia are widely distributed in Montana.

The main laboratory criterion for identification of cultures of the two varieties is that minimal doses of the first type will cause fatal infection in domestic rabbits, whereas with the other type moderate doses of the organism will infect but not kill domestic rabbits. The animals often do not show visible signs of illness. Most of our cultures are readily classified in one or the other of these two types. However, Russian workers have proposed names for several additional varieties of the organism and other workers in the United States have suggested there are various intergrades between the two fairly well-defined subspecies.

Intensive study on tularemia in semi-aquatic mammals and in the water habitat has necessitated modification of some of the epidemiological concepts expressed by Jellison and Parker (1945), but has greatly expanded our knowledge of the disease. This type appears to be entirely independent of ticks and cottontails in North America. Hundreds of cases have been reported in trappers in Canada (Wood, 1951); also skin and serological tests indicate prevalence in Alaska (Philip et al, 1962) where recognized clinical cases are extremely rare.

We have isolated and described a new organism from a Utah water sample which is very similar to **F. tularensis** but can be distinguished by cultural and serological tests. This has been called **Francisella novicida**. It is pathogenic for mice, hamsters, and guinea pigs in the laboratory but has not been definitely associated with disease in man or animals in nature (Larson, Wicht, and Jellison, 1955).

The American muskrat, an important source of tularemia infection for man. U. S. Bureau of Sport Fisheries and Wildlife photo.

TULAREMIA IN SEMI-AQUATIC MAMMALS AND THE PRESENCE OF F. TULTRENSIS IN WATER

Prior to 1939, a few cases of tularemia in the United States had been attributed to contact with muskrats and first among these were two cases reported by Dr. Harold Schwartz of Butte (1929). He treated two Japanese section workers who skinned a muskrat and both became infected. These cases were not considered unusual because the muskrat is a typical rodent, even though it prefers a semi-aquatic habitat. The muskrat, however, is exceptionally free of ticks, fleas and lice which we usually think of as being carriers or transmitters of tularemia.

In the U.S.S.R. and in many European countries, there is an animal called the water-rat or vole-rat, **Arvicola terrestris**, also known as **Arvicola amphibius**, that is a counterpart of our muskrat but is smaller. It is extremely abundant at times and is hunted and trapped by thousands for its fur. The muskrat has also been introduced into Europe and U.S.S.R. and now occupies the same habitat as the water-rat. Russian investigators had reported at least two major epidemics involving 200 and 800 cases respectively in water-rat hunters prior to 1929.

In 1935 two Russian scientists observed and reported (1936) an epidemic of at least 43 cases in communal farm workers and attributed infection to drinking water from a small stream. Portal of entry appeared to be mouth and throat. The organism was isolated from the stream by animal inoculation.

In 1939, four or five dead beaver were reported in the vicinity of Roundup by local game wardens. We were already aware of the Russian experiences. Autopsies, animal inoculations and cultures soon proved the beaver had died of tularemia. This was the first of many beaver that were to be found dead within the next few years. The first water samples taken from ponds where beaver were found dead along the stream bed of the Musselshell River produced tularemia in laboratory animals. **This was the first isolation of F. tularensis from water in North America.** Reports of beaver fatalities and human cases from beaver and muskrat contacts were quite numerous through 1943 and have been sporadic since that time.

Locations of epizootics in muskrats and beaver, 1938-1942.

Swamp near Florence, Ravalli County, where epizootic in muskrats occurred in 1949.

Intensive studies on this phase of tularemia epidemiology in Montana, Idaho, Oregon, and Utah were continued for several years and led to many interesting observations, which were published in a National Institute of Health Bulletin, No. 193.

In one drainage area east of Hamilton, 1,198 water samples were taken during a 16-month period. These were tested for presence of **F. tularensis** by injection into guinea pigs. 703 of the 1,198 samples, or 58%, infected one or more test animals. Several water samples were taken each month from another small stream in the same general area, and at least one sample was positive each month for 16 consecutive months, winter and summer.

Infection has resulted from water samples taken in mid-stream of flood-swollen creeks and rivers; it has been demonstrated in samples from clear mountain streams, spring-fed streams (a few hundred yards below the spring), marshes, stagnant ponds, ponds along river channels at low water, from kitchen faucets of domestic, rural water supplies and from the historically famous Frog Pond on the campus at Montana State University, Bozeman.

If field mice, muskrats or beaver dead of tularemia are found adjacent to or in streams, it is good assurance that the water will prove to be infectious; however, many streams carry the organism where we can find no evidence of animal mortality.

Dead beaver, because of their large size, were the most common indicators of epizootic areas and, where these animals were obtained fresh, they almost always yielded **F. tularensis** cultures. Muskrats found dead by trappers were also a reliable source of infection. Close examination of stream banks and adjacent meadows sometimes resulted in finding freshly dead and infected field mice, **Microtus** spp. Illness in trappers was also an indication of epizootic areas.

At this time we have no logical explanation for the presence of such a fastidious organism as **F. tularensis** in ponds, streams and rivers throughout northwestern United States. We do not believe the contamination comes from decomposing animal carcasses.

Tularemia had been conspicuously scarce or absent in the New England states, exclusive of New York, prior to 1968 and New York had reported only 66 cases up to 1944. However, in 1968, the largest outbreak of tularemia in man associated with aquatic mammals in North America occurred suddenly in Vermont, a state that had no previous record of tularemia (Young et al, 1969). Forty-seven cases appeared within a few weeks in persons who were trapping and skinning muskrats. There were no fatalities but 14 patients had severe prostrating illness, a few had extremely mild infections. **F. tularensis** was isolated from one human case, from four of 78 trapped muskrats and from an unspecified number of mud and water samples. No isolations were made from rabbits.

In contrast to some epizootics and epidemics which we have studied in the west, evidence of die-off in the muskrat population was "conspicuously absent." Both trappers and dealers agreed muskrats were more abundant in 1968 than in the previous five years. The report available (Young et al, 1969) does not mention finding a single dead animal in the infected area.

For example, McDermid (1946) reporting on the epizootic in muskrats in Horicon Marsh, Wisconsin, stated, "State clean-up crews picked up 1,114 dead muskrats from the Horicon Marsh area and burned the carcasses."

Dozens of dead beaver and hundreds of dead muskrats were observed in some previous epizootics in Oregon, Utah, Montana, Wisconsin and Canada (Parker et al, 1951).

We have referred several times to the conclusion that isolates of **F. tularensis** from water, muskrats, and beaver are of somewhat lower virulence than isolates from sheep, ticks, and rabbits in the United States. By 1951, we had reports of over 100 cases in beaver and muskrat trappers. We had no record of a fatal case from these sources, whereas a case fatality rate of 5% to 7% (mainly rabbit contact cases) was expected prior to use of antibiotics in treatment. Many cases (1938-1951) were very mild and ambulatory. Some trappers continued on their regular daily trap rounds and

Emery Buker collecting water samples for laboratory tests. This stream near Hamilton carries tularemia organisms at all seasons of the year.

would not have been diagnosed, except for intensive case finding and questioning of trappers in epizootic areas. On the other hand it would be difficult to convince some trappers that they had a "mild case of tularemia." This would especially apply to an elderly trapper who survived a severe infection by himself in winter in an isolated cabin near Klamath Falls, Oregon. He had little recollection of the terrible ordeal when he finally made his way back to civilization.

TULAREMIA IN OTHER ANIMALS

In 1945, Burroughs and his associates compiled a list of the vertebrates known to be naturally infected from all continents. This included 48 species and 27 genera. Some of these had been reported as infected in a single instance only. Some were known to be important reservoirs and to have experienced widespread epizootics.

Sheep, cattle, horses, rabbits, muskrats, beaver, field mice, and sage grouse have been discussed in this paper.

There are reports in the literature of infection in dogs and cats usually from eating infected animals. Information on cats up to 1929 was summarized by Dr. Simpson who stated, "Francis places the cat among mildly susceptible animals." Individual reports, mostly based on laboratory tests, were very conflicting. Some cats apparently died from natural infection but the proof was not conclusive. In laboratory tests, a few kittens and even adults died after eating infected tissue, but other cats remained well. It would seem that some retesting of cats would be desirable using isolates of known virulence, measured doses of inoculum and more standardized groups of experimental animals. About the same could be stated in regard to dogs and tularemia. One of the important roles assumed by both dogs and cats is catching or retrieving sick or dead animals and bringing them home and exposing people.

About 1930, I obtained a tame cub bear from the Fish and Game Department for experimental work. It was kept at the laboratory for several weeks and then fed a dish of ice cream garnished with chopped spleen and liver from a tularemic guinea pig. The bear became very sick but recovered and showed a strong agglutination titer for **F. tularensis.**

Epizootics in ranch mink being fed wild jack rabbit meat have been experienced in southern Idaho; many mink died.

THE HUMAN DISEASE

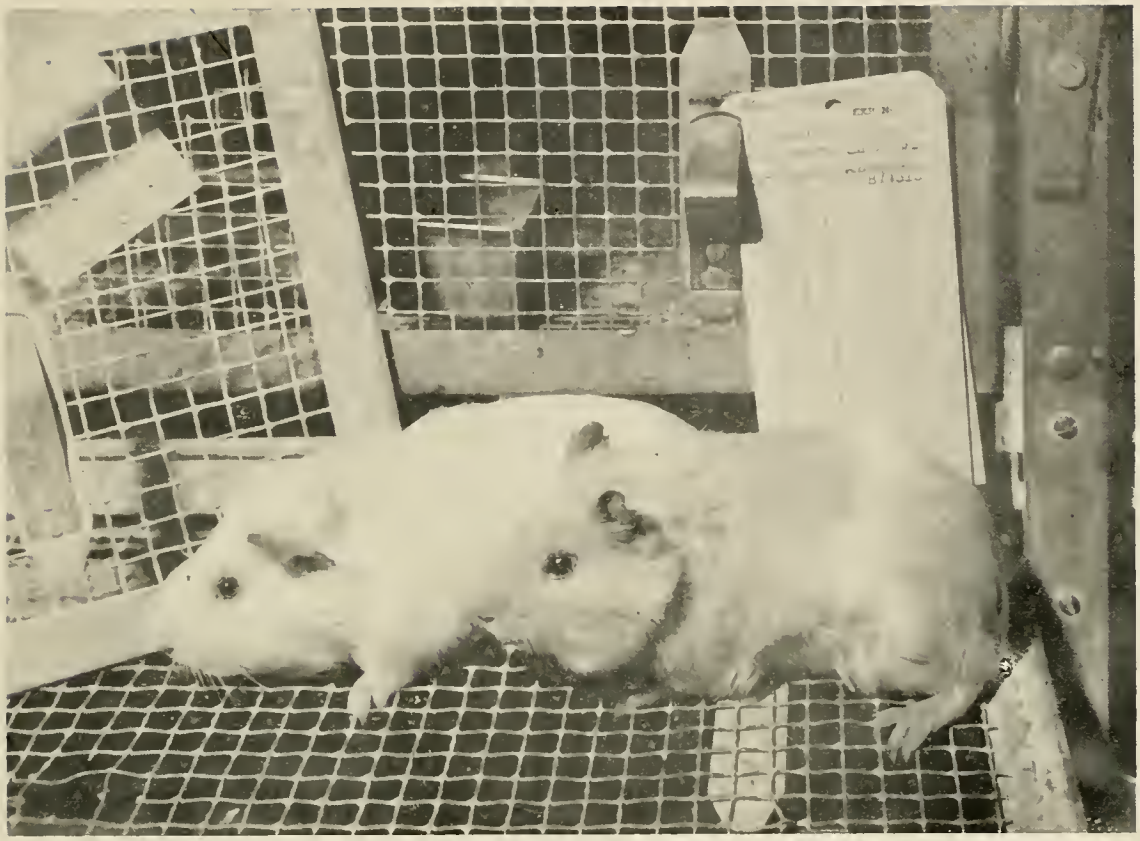
In human tularemia the first sign of disease is usually marked inflammation at the point of infection, a wound, tick bite or deerfly bite. This lesion rapidly develops into a prominent ulcer or "boil" and is accompanied by swelling and tenderness of the regional lymph nodes. Systemic symptoms, high fever, headache, chills and prostration appear early —at times suddenly. Without antibiotic treatment the course of illness may last several weeks or even months. Involved lymph nodes may become very large and painful and are often surgically treated for drainage or complete removal. Spontaneous rupture and persistent drainage is not unusual. Complete recovery may take months. The initial lesion heals slowly and often a center of dead tissue sloughs away leaving a characteristic "punched-out ulcer" and a permanent scar.

Many variations in clinical manifestations have been recognized, including multiple initial lesions, septic sore throat at onset, and systemic illness without obvious indication of portal of infection. The latter is referred to as typhoidal type and includes a few rapidly fatal family outbreaks from eating poorly cooked rabbit. Eye infection with prominent involvement of local lymph nodes is well recognized and results from rubbing infective material into the eyes. Degrees of illness range from slight inconvenience to rapidly fatal disease.

Before antibiotics were developed, no specific treatment was available and cases in the United States were frequently fatal. Now, several antibiotics have proved to be extremely effective and immediate dramatic cures are observed even in very severe cases. Streptomycin and tetracycline preparations are recommended and may be administered by mouth or injection. Penicillin is not effective.

TULAREMIA AND PLAGUE

It is very difficult or impossible for even an experienced laboratory worker to distinguish between tularemia and plague in the autopsy of a wild or laboratory animal. Tularemia was first described as a plague-like



Guinea pigs that survived tularemia infection because of streptomycin treatment, 1945.

disease of rodents in California where it was encountered in ground squirrels that were being examined for plague. It could be distinguished from plague only by culture and by microscopic examinations.

There is a story that a culture and infected laboratory animals were used in a West Coast medical school as demonstrations for tularemia, until one skeptical student identified the culture as the plague bacillus.

In man the initial illness and presence of buboes or enlarged lymphatic nodes are very similar in plague and in tularemia. Without antibiotic treatment, plague would be about 50% fatal, tularemia 5%. Plague can appear in a pneumonic form that is highly contagious and 90% fatal; tularemia may also be pneumonic but is not known to be contagious in humans.

This distinction is not just academic or applicable to California. In 1934, 1935, and 1936 plague was found to be widespread in ground squirrels in Beaverhead and Madison Counties, Montana. Great die-offs of ground squirrels were observed in Beaverhead County and plague was found in many squirrels. In November, 1968, a fatal case of plague occurred near Salmon, Idaho, and infection was attributed to a snowshoe hare which the hunter shot and tied to his saddle horn. This was the first time in North America that the snowshoe hare had been incriminated in plague although cottontails are a recognized source of human infection in Arizona and New Mexico in recent years. A fatal case of plague was reported near Boise, Idaho, in 1939, but the source of infection was more obscure.

Plague was also present in ground squirrels in Alberta, Canada, north of Montana.

LITERATURE

For the benefit of anyone who may become especially interested in tularemia, I would like to state that there are 15 bound volumes of reprints on tularemia in the Rocky Mountain Laboratory Library. There are also several books on the subject. Numerous publications on the disease are still available for distribution from the Laboratory and from my personal library. In my personal collec-

tion, designated as the Parker-Davis Memorial Library, I have the library of the late Dr. Edward Francis who described and named tularemia in 1921. This collection contains his laboratory and field notes, correspondence, manuscripts, pictures and lantern slides.

A bibliography on tularemia prepared and published in mimeographed form by the Technical Library, Camp Detrick, Fredrick, Maryland, in 1952, contains 81 pages of references.

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TURTLES OF MONTANA

By JEFFREY H. BLACK, University of Oklahoma
. . . Photos by Author

Most children have had pet turtles, but little do they realize that their pets are members of an ancient and long-lived group of reptiles. Fossil relatives of turtles are found in rocks at least 175 million years old. Turtles today are found on every continent and in almost every area where winter is not perpetual.

There is considerable folklore associated with turtles. Many Asian people believed that the earth rested upon the back of one of these reptiles. Numerous stories are told of the strength and longevity of turtles and most everyone has heard the story of the race between the tortoise and the hare. Ceremonial rattles made of dried turtle shells filled with pebbles figure in the rain dances of the southwestern Indians.

One might wonder if a "turtle," "tortoise" and "terrapin" are the same thing. All can properly be called turtles, but the edible fresh water kinds sold in markets are known as terrapins, while the land turtles with stump-shaped hind legs may be called tortoises.

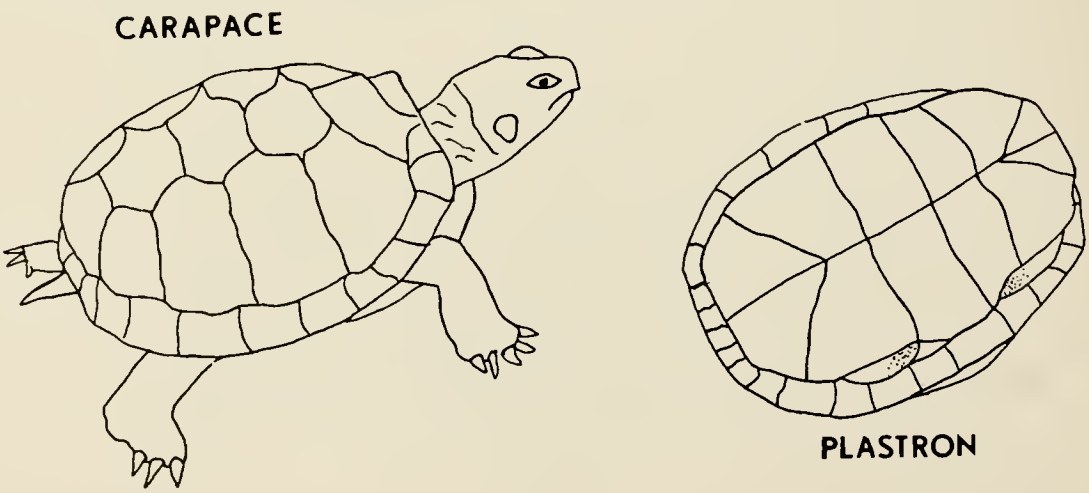
Turtles belong to the Class Reptilia which also includes snakes and lizards. The major difference between turtles and other living reptiles is the shell covering the body. The shell is of two parts, an upper rounded **carapace** and a flatter ventral **plastron**. The carapace and plastron are connected on each side by a **bridge**. The shell is of bony plates, covered by horny plates and provides protection against predators, dessication, and other dangers.

Turtles see well, their sense of smell is adequate, and their hearing is well-developed. They lack teeth, but have jaws covered with sharp horny beaks.

They are the only vertebrates in which the limb attachments are inside the ribs. All have two pairs of legs with five fingers and toes bearing claws. The tails of the males are usually longer than those of females and the anal openings are often situated farther out on the tails of males than on the females. These external characteristics will usually separate the sexes.

The eggs of turtles are adapted for development on land and will not develop in water. Their eggs have membranes homologous with those of bird eggs and fetal membranes of mammals. The ability to produce eggs has allowed turtles to become independent of water for breeding and to be the first large group of vertebrate animals to occupy the land.

Turtles are beneficial to man because of their scavenging habits. They also consume large numbers of mosquito larvae and other insect pests, and have potential food value to humans.



COMMON SNAPPING TURTLE
(Chelydra serpentina serpentina)

Distribution:

The common snapping turtles are closely restricted to water in the eastern half of Montana. They may inhabit lakes, rivers, slow streams, ponds and marshes.

Description:

The large head with powerful jaws, the serrated rear margin of the carapace, a long tail with a saw-tooth crest, and a neck covered with many warty tubercles are distinguishing characters. The plastron is cross-shaped and covers only part of the underside. The common name "moss-backs" refers to a mat of firmly attached algae that flourishes on the backs and on the upper parts of the tails of many individuals.

Breeding:

Mating occurs in the spring or early summer and eggs are laid from May to October. The nests are dug by the females some distance from water; 8 to 80 eggs are laid by an individual in the earth 2-5 inches deep. Hatching occurs in about 4 months.

Habitat:

The preferred habitat of the common snapping turtles is almost any kind of aquatic habitat. They inhabit water where aquatic plants are abundant and where there is a soft bank or bottom for hibernation and hiding.

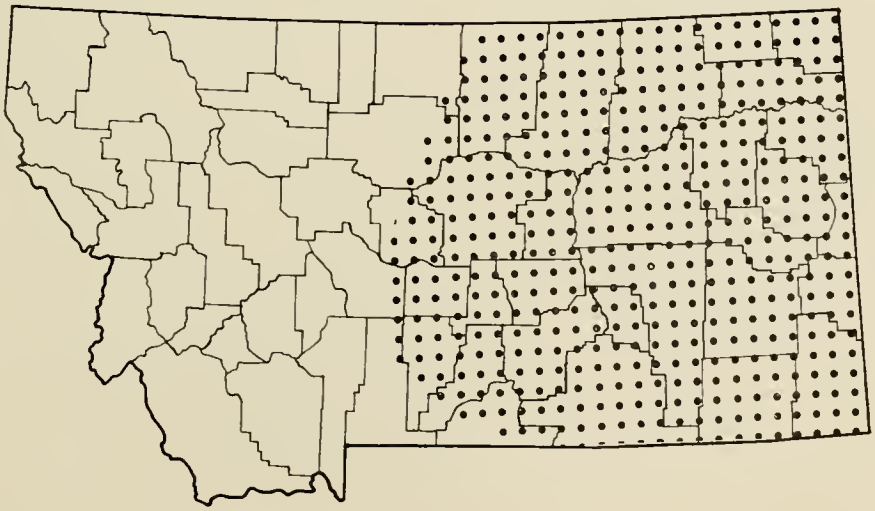
Feeding:

These turtles are adept at catching anything that swims, but there need be little concern as to the adverse effect of snapping turtles on game fish in wild waters of Montana. It is a conservative estimate that not more than one game or pan fish is eaten per day by an individual snapping turtle. They also feed on frogs, crayfish, other reptiles, birds and aquatic plants.

Behavior:

The common snapping turtles probably hibernate in Montana from October to May. Hibernation occurs under water and beneath bottom mud or debris. Individuals may sun themselves on land or may float at the water's surface.

The temperment of snapping turtles is well known. They can strike with the speed of a rattlesnake and are often ill-tempered and very apt to bite. The snapping turtles not only defend themselves with their jaws, but also keep predators at a distance by secreting a powerful musk. They can be carried safely by the tail, but **be careful!**



WESTERN BOX TURTLE
(Terrapene ornata)

Distribution:

The occurrence of western box turtles in Montana needs confirmation. The only record of their occurrence is that of Dr. F. V. Hayden who reported them near the Yellowstone River in Montana, 1871. If present, they probably inhabit the southwestern counties.

Description:

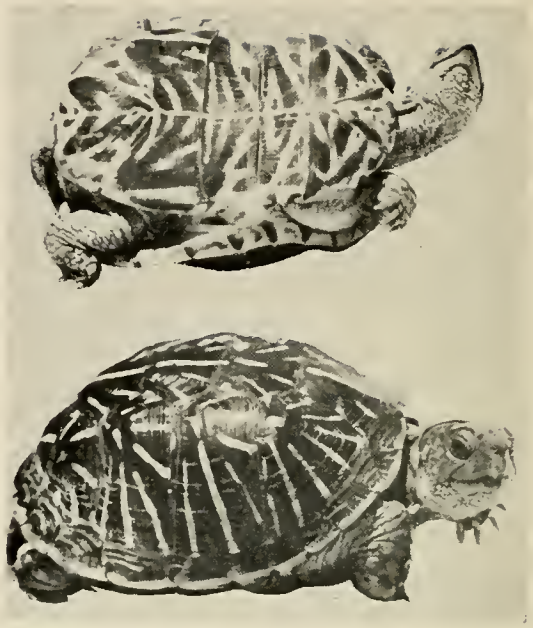
These are the only strictly land-going turtles in Montana and are distinguished by their rather high carapaces and stubby feet which are adapted for walking on land. They have shells with yellow striping on dark backgrounds and the plastrons are hinged in front allowing the turtles to completely enclose themselves within their shells. The plastrons are yellowish, with or without dark bars. Males have the first toenails of hind feet turned inward, reddish irises of the eyes and reddish spots on the forelegs which usually distinguishes them from the females.

Breeding:

These turtles breed during the spring and fall and eggs are laid in nests from May through July. Around 3 to 5 eggs are laid by each female. During courtship the males tap the carapaces of the females with their plastrons and may bite at their shell margins.

Habitat:

The western box turtles are primarily inhabitants of the plains regions where there is rolling country, grass, low bushes, and sandy soil. They are rarely found in wooded areas.

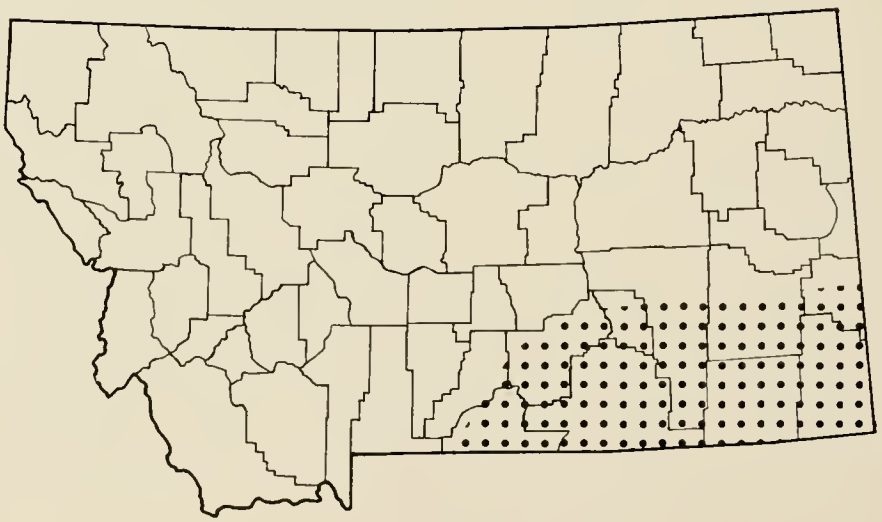


Feeding:

Western box turtles primarily feed upon plant materials and also beetles and other insects. They have great value as destroyers of insects.

Behavior:

During warmer weather, most activity occurs during the morning and late afternoon. During the heat of the day, these turtles seek shelter under objects, bushes, or in self-made burrows. Hibernation occurs during the winter when turtles can burrow up to two feet beneath the soil.



PAINTED TURTLE
(Chrysemys picta)

Distribution:

Painted turtles are the most commonly seen turtles in Montana and occur throughout the state excepting at very high elevations in the western mountains.

Description:

These are our most brightly colored turtles. Yellow stripes adorn the heads and legs and a red spot or bar is situated behind each eye. The carapaces are low and their margins may be marked with yellow. The plastrons are red or orange in young turtles with the dark markings well-developed. Males have longer nails on their front feet than do the females.

Breeding:

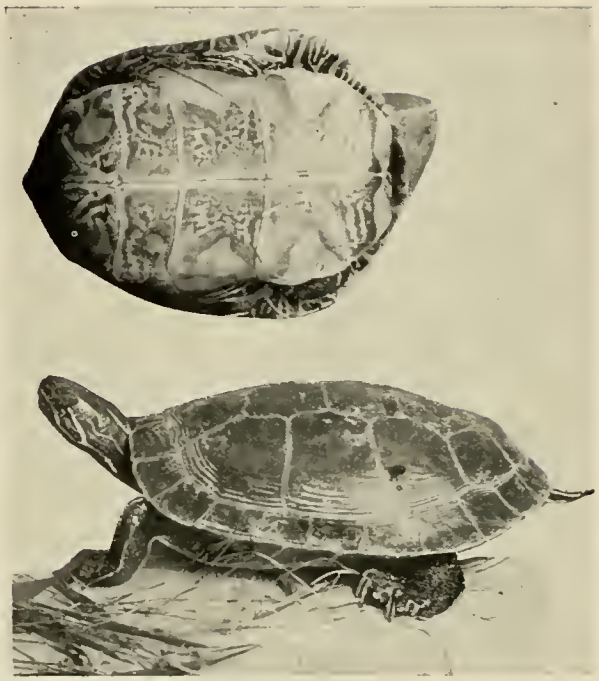
Males have long claws on the forefeet which are vibrated rapidly besides the cheeks of the females during courtship. Eggs are laid during May or June in nests on the shore. Eggs, numbering from 6 to 20 are buried in the earth 2 - 5 inches deep and hatch in about 4 months.

Habitat:

The preferred habitat of painted turtles in Montana seems to be practically any body of water. They are found in large bodies of water such as Fort Peck Reservoir to water-filled roadside ditches. These turtles are associated with lakes, ponds, rivers and streams in Montana. Painted turtles are frequently on land moving between adjacent bodies of water. Home ranges may include parts or all of several water bodies.

Feeding:

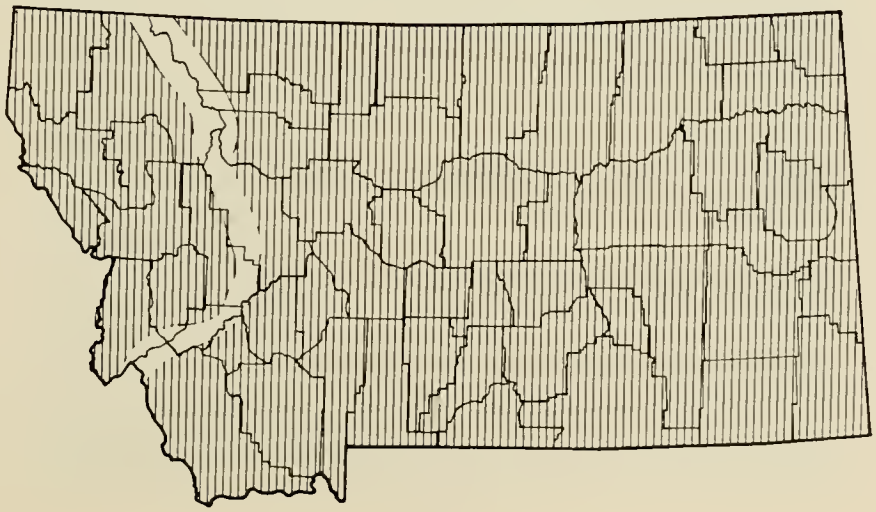
Painted turtles probably use smell and sight as the primary methods of locating food.



Food is eaten whole or is torn with the aid of the front feet. The painted turtles are more or less neutral in their food habits, consuming large quantities of plant food, crayfish, snails, clams, tadpoles, and small fish.

Behavior:

These turtles are often seen in groups sunning on muddy banks, on logs or other objects. They are quite wary and immediately enter the water and swim to the bottom when disturbed. They hibernate during the winter in the mud or debris on streams, lake, or pond bottoms.



WESTERN SPINY SOFTSHELL
(Trionyx spiniferus hartwegi)

Distribution:

In Montana, the range of western spiny softshell turtles lies in the southeastern part of the state. The northern boundary appears to be in Roosevelt, Valley, Phillips, Blaine, Chouteau, and Cascade Counties. Their range extends west to Canyon Ferry Reservoir and then south to the Wyoming border.

Description:

The western spiny softshells are very different from other Montana turtles. These are the "pancake" turtles which have very flat, flexible shells. The shells are covered with leathery skin and have flexible edges. The carapaces are marked with numerous dark spots; their necks are long and the snouts are proboscis-like with nostrils opening at the ends. The feet of these reptiles are broadly webbed and well adapted for pushing these very aquatic turtles at high speed through the water.

Breeding:

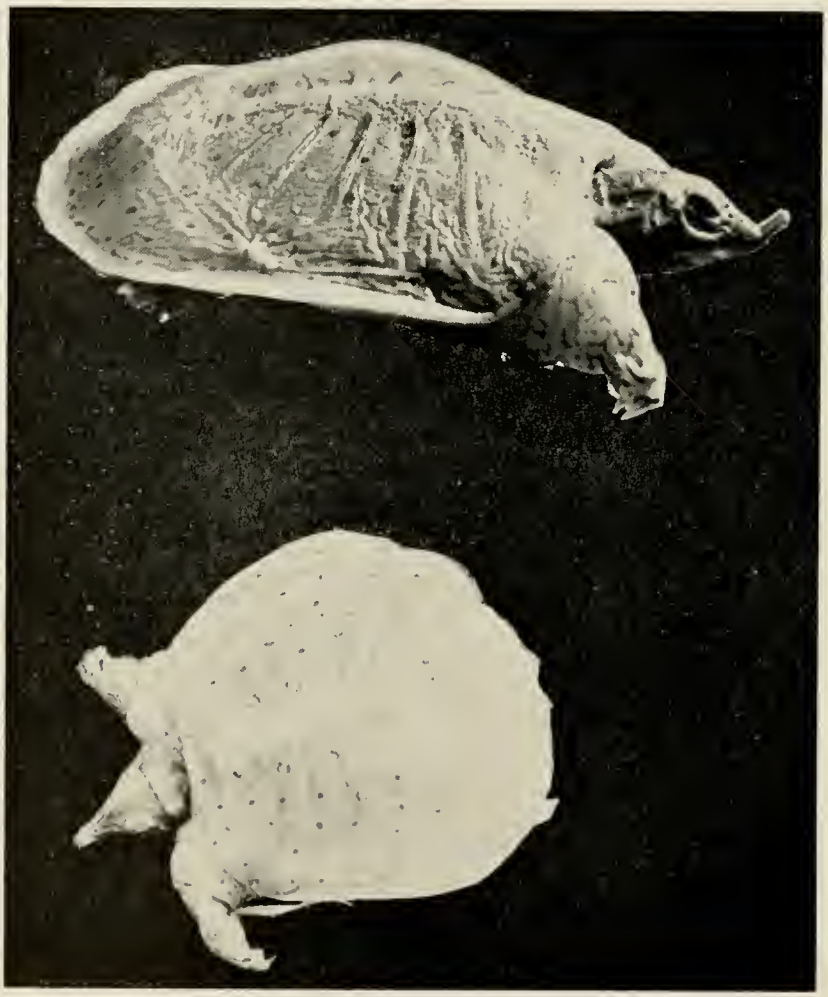
Softshell turtles seldom leave the water except to lay eggs—March to July. Sandy soil is preferred for the nests. Eggs number about 10 to 30.

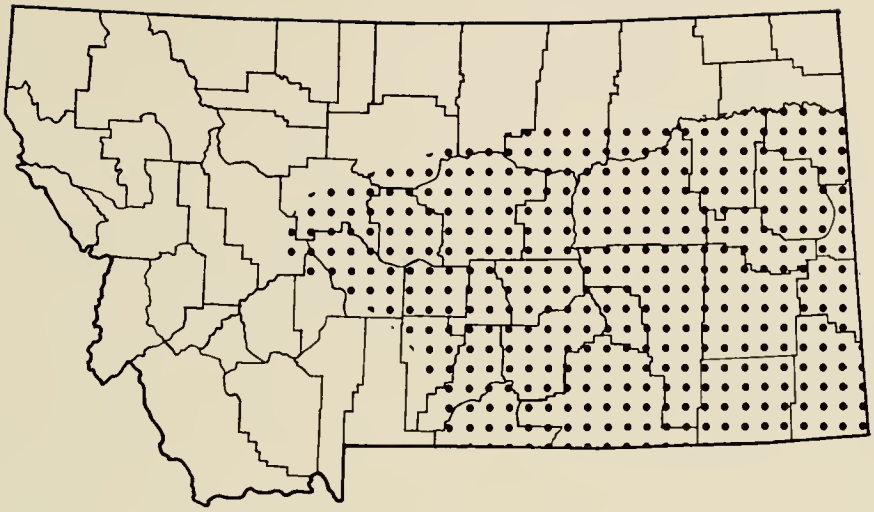
Habitat:

These are highly aquatic turtles and are found primarily in rivers and streams, but also in ponds, lakes and ditches. They appear to prefer waters with a bottom of gravel, sand, silt or mud.

Feeding:

These are primarily carnivorous turtles. They feed upon insects, frogs, tadpoles, snails,

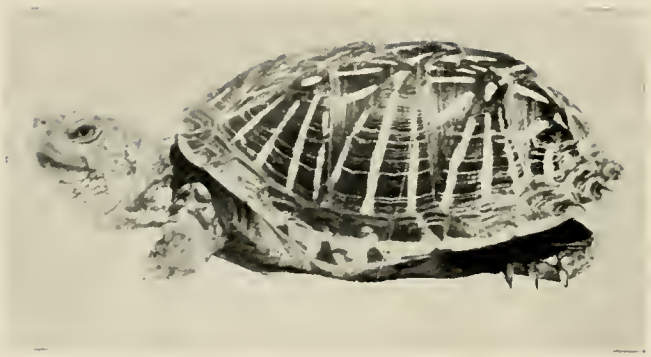




crayfish, fish and earthworms, and occasionally aquatic plants.

Behavior:

Hibernation occurs in the sand or muddy bottoms of their aquatic habitats. They often lie in shallow water buried in mud or sand with their heads extended to the water surface. They should be handled with care as they can inflict painful bites.



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